Jurnal Kejuruteraan SI 3(1) 2020: 29-34
https://doi.org/10.17576/jkukm-2020-si3(1)-05

STEM Outreach Program of Smart Control Helicopter Competition in Malaysia: A Descriptive Analysis

Sabirin Abdullah[a*], Roslinda Rosli[b],Gan Kok Beng[c], Mardina Abdullah[d], Lilia Halim[e] & Norisza Dalila Ismail[f]

[a]*Space Science Centre (ANGKASA) - Institute of Climate Change, Universiti Kebangsaan Malaysia, UKM Bangi, Malaysia*
[b]*Centre of Learning and Teaching Innovation, Faculty of Education, Universiti Kebangsaan Malaysia UKM Bangi, Malaysia*
[c]*Centre of Advanced Electronic and Communication Engineering (PAKET), Faculty of Engineering and Built Environment Universiti Kebangsaan Malaysia, UKM Bangi, Malaysia*
[d]*Space Science Centre (ANGKASA) - Institute of Climate Change & Centre of Advanced Electronic and Communication Engineering (PAKET) - Faculty of Engineering and Built Environment Universiti Kebangsaan Malaysia, UKM Bangi, Malaysia*
[e]*Centre of STEM Enculturation, Universiti Kebangsaan Malaysia, UKM Bangi, Malaysia*
[f]*Politeknik Banting Selangor, Banting, Malaysia*

**Corresponding author: dr_sabirin@ukm.edu.my*

Received 30 October 2019, Received in revised form 03 April 2020
Accepted 15 May 2020, Available online 30 September 2020

ABSTRACT

The objective of the paper is to present findings of a Science Technology Engineering and Mathematics (STEM) outreach program on Smart Control Helicopter. The program involved 27 school students in Selangor, Malaysia where they learned a microcontroller board called Arduino to control mini helicopters. Students had exposed to the procedures to assemble simple circuits for the control system, the connection process of the circuit to a microcontroller, and communication with the computer. The activity has equipped the students with basic knowledge in performing accurate programming to maneuver a mini helicopter. A few university students assisted the learning activities based on a developed module. The program was conducted in the form of a competition to self-motivate the students. The students completed a questionnaire and quiz on the technical knowledge of technology and electronics. As a result, students were able to gain knowledge on the related skills and showed active participation during the hands-on activities.

Keywords: STEM; project-based learning; awareness in science and mathematics; Arduino

INTRODUCTION

Nowadays, students' interests in science and mathematics are not very encouraging. Due to this statistic, this is also affecting the low number of science classes in schools mostly student interest in Science, Technology, Engineering, and Mathematics (STEM). The education system is seen as a significant means of improving student achievement in STEM-related fields. Hence, one of the initiatives from the Universiti Kebangsaan Malaysia (UKM) is providing grants to researchers for conducting activities that focus on STEM project-based learning. The smart control helicopter program is one of the outreach programs to boost students' interest and awareness in learning science and mathematics. Initially, the smart control helicopter program has been initiated since 2012 with the help of an ex-NASA astronaut Dr. Daniel T. Barry and the program have been continuously received much attention from the schools (Abdullah et al. 2018).

Many STEM outreach programs have been conducted to provide a meaningful experience to students on the introductory of engineering topics (Nadelson & Callahan 2011). Past studies have shown that these programs provided significant evidence on the impact of hands-on learning in promoting student awareness and knowledge of the STEM field (Yildirim, 2016; Nadelson & Callahan 2011). For instance, in a study comparing two engineering outreach programs, (Nadelson & Callahan 2011) found the participants' engineering perceptions and attitudes were increased positively after both events. Similarly, results from meta-analyses research of Becker & Park (2011) and Siregar et al. (2019) showed that integrative approaches among STEM subjects have a positive impact on students learning. Meanwhile, in Malaysia, the opportunity to be involved in the university-led STEM outreach programs are still limited. According to Siregar et al. (2019), several factors, including funding, staffing, service delivery, and long-term program sustainability, had impacted the university's commitment to support the STEM outreach programs globally. Hence, the present study aims to illustrate hands-on activity included through the smart control helicopter outreach program.

METHODOLOGY

PROGRAM DEVELOPMENT

The Smart Control Helicopter is part of the university-led programs to encourage students' interest in STEM subjects. Importantly, the Smart Control Helicopter adapted learning through a game competition, in which students participate in well-planned hands-on activities based on a learning module. Experts have developed the module in the field, and each chapter includes exercises to examine students' basic knowledge of the topic. The hands-on activities in the module provided students the input on the basics components and programming using an Arduino board. The module is to assist the student and also the facilitator in the program in an easy explanation. The module includes a hands-on activity that can be done by the student from the instructor and facilitator help. The activity is from basic electronics to programming software for the competition.

The Arduino board is a programming microcontroller, which is an inexpensive and affordable learning tool for students to develop their thinking skills through the construction and programming the electronic devices (Louis, 2016). Figure 1 shows the Arduino component (microcontroller) along with a basic circuit assembly, and Figure 2 shows the mini helicopter for the hands-on activities.

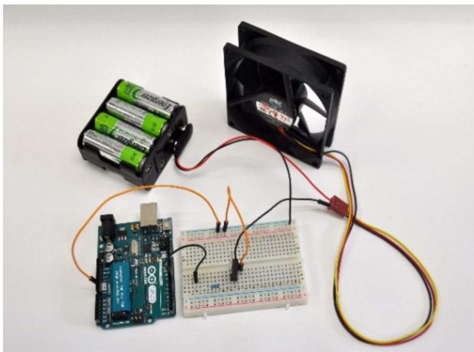

FIGURE 1. Circuit assembly using Arduino board

FIGURE 2. Mini-helicopter use in this competition

PARTICIPANTS

Twenty-seven students of the selected schools in Selangor, Malaysia, were invited to participate in the program: Sekolah Menengah Kebangsaan (SMK) Sungai Ramal, SMK Engku Husain, SMK Gombak Setia, SMK Darul Ehsan, and SMK Sungai Rawang. Two groups of three students represented each school in which the school administration decided in the student selection. The program was initiated with a 1 1/2 half-day workshop at the university, and teachers from the respective schools accompanied all students during the activities.

PROCEDURES

The workshop session was conducted in 3rd to 4th April 2019 that focused on building programming to monitor a mini helicopter for presenting the output at a competition level. A total of nine groups of students was formed and actively involved during the workshop session. The group members were required to work cooperatively and effectively with their teamwork to complete the hands-on task. Before the workshop, a short briefing was conducted by two experienced speakers to provide fundamental knowledge of a smart control mini-helicopter. For instance, the students were taught on basics movement of a mini-helicopter and were guided in maneuvering the helicopter using a controller. Then, each group of students was given necessary electronic components, including an Arduino board, circuit, and mini-helicopter. The university members and polytechnic students were part of the facilitators in guiding the participants (as shown in Figure 3) to complete their tasks and to present the outcome in the competition.

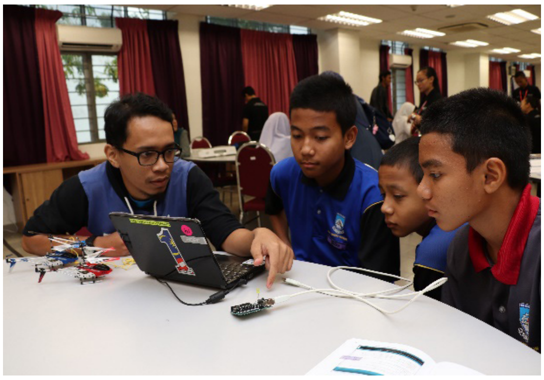

FIGURE 3. Facilitator discuss with the student

During the first session of the workshop, the participants built a simple circuit with visible blinking LED lights. They were exposed to different circuit components and the procedure to program a microprocessor. Once the participants were able to achieve the necessary knowledge, they were shown to a process of building a more complex circuit. Once the circuits were assembled and tested, the workshop session was focused on the discussion of control systems and autonomous robotics. Each team loaded the software onto the microprocessor that later issued commands to the mini-helicopter through the IR LED array circuit. For a final demonstration, each group chose a more complex maneuver to fly the helicopter and then programmed their system to perform that operation.

Each group was assisted by one facilitator who responsible for providing excellent advice on the task to group members. Through the close guidance from the facilitators, students were able to practice and modify the Arduino programming to accustom the tasks, as shown in Figure. 4. At the final stage, the students presented the output of the workshop session through the smart control mini-helicopter competition in which a few the expert juries from the university evaluated students' work based on guided criteria in Figure 5.

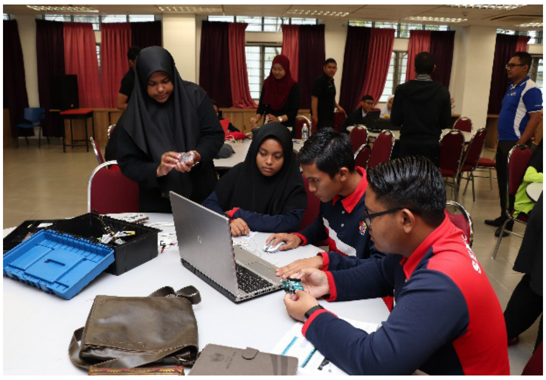

FIGURE 4. The student is practicing using the Arduino board and the circuit

FIGURE 5. Student present their result in the competition

After the competition, the students were asked to complete a survey questionnaire, which has seven items on seven Likert scale items ranging from "1" as "Strongly disagree" to "5" as "Strongly agree". Based on the analysis, it was revealed the reliability value of Cronbach Alpha at 0.609. In addition, the students also completed a quiz, which was administered before (pre-test) and after (post-test) the competition to examine the students' technical knowledge of technology and electronics. The quiz consisted of 15 items on electrical and electronic (5 items), microcontroller (5 items), and programming (5 items) with four multiple-choice responses. Most of the item questions during the pre and post quiz were modified slightly for assessing the same concepts, yet to prevent memorization.

RESULTS AND DISCUSSION

The demographic profile in Table 1 shows 15 males and 12 females who were at the age of 14 and 15 years old involved in the program.

TABLE 1. Demographic profile

	Frequency	%
Male	15	55.6
Female	12	44.4
Total	27	100

TABLE 2. Questionnaire responses

Item Description	Responses			
	Disagree	Do not know	Agree	Strongly agree
I can identify several types of electronic components and their functions.		7 (25.9%)	15 (55.6%)	5 (18.5%)
I can build a simple electronic circuit.	1 (3.7%)	2 (7.4%)	19 (70.4%)	5 (18.5%)
I need guidance from Mentor/ Facilitator to complete the task in this program.	1 (3.7%)	2 (7.4%)	10 (37%)	14 (51.9%)
I learned teamwork skills through this project.		1 (3.7%)	11 (40.7%)	15 (55.6)
I am able to understand and modify the coding of the program for this project.	1 (3.7%)	4 (14.8%)	17 (63%)	5 (18.5%)
This competition has inspired me to learn more on our own and take the skills learned in the workshop to higher levels.		2 (7.4%)	9 (33.3%)	16 (59.3%)
After doing activities in this program, I am interested in furthering my studies in the science/ technology stream.	1 (3.7%)	8 (29.6%)	9 (33.3%)	9 (33.3%)

The data collected from the questionnaire and quiz were analyzed descriptively using SPSS version 23. For the questionnaire, the total maximum score of all responses equals 35 and a minimum score of 7. Based on the analysis, the mean of the score was 29.3, and a standard deviation of 2.7. The detailed report per item is shown in Table 2. The program has received positive responses from most of the participants in which similar to the results from past studies of Yildirim (2016), Nadelson & Callahan (2011), Becker & Park (2011), and Siregar et al. (2019). In the present study, the majority of participants prefer to choose a score between "Agree" and "Strongly agree".

Meanwhile, there is none responded to the "Strongly disagree" point of the Likert scale. The responses showed many students were affirmative with the hands-on activities of the Smart Control Helicopter Competition program.

TABLE 3. Quiz responses

Post items	Pre quiz		Post quiz	
	Correct	Incorrect	Correct	Incorrect
Part 1: Electrical and electronic				
1. Arduino is a ____________ working like a small computers that can be used to process information.	6 (22.2%)	20 (74.1%)	22 (81.5%)	5 (18.5%)
2. The symbol  is for___________.	17 (63%)	10 (37%)	22 (81.5%)	5 (18.5%)
3. The color code for a resistor with a value of 100 Ohm is _______.	17 (63%)	8 (29.6%)	9 (33.3%)	17 (63.0%)
4. The three-legged component is known as ________.	18 (66.7%)	9 (33.3%)	24 (88.9%)	3 (11.1%)
5. Transistors have the following legs as ___________.	3 (11.1%)	23 (85.2%)	15 (55.6%)	11 (40.7%)
Part 2: Microcontroller				
6. CPU (Central Processing Unit), RAM (Random Access Memory), ROM (Read Only Memory), I / O device, serial port, parallel port and timer are part of the ___________.	20 (74.1%)	7 (25.9%)	9 (33.3%)	17 (63.0%)
7. Get>decode>executable, is a command run by________.	9 (33.3%)	18 (66.7)	9 (33.3%)	18 (66.7%)
8. Temporarily storing data is work done by ________.	13 (48.1%)	14 (51.9%)	18 (66.7%)	9 (33.3%)
9. Movement sensors are a component of ___________.	6 (22.2%)	21 (77.8%)	11 (40.7%)	16 (59.3%)
10. Based on the following diagram, pins 11, 14, 21-24 are the connections for the __________ components for proper installation in the microcontroller electronic circuits.	11 (40.7%)	16 (59.3%)	8 (29.6%)	19 (70.4%)
Part 3: Programming				
11. A set of instructions for the micro-controller is known as ____________.	27 (100%)	0	23 (85.2%)	4 (14.8%)
12.The parameter that can be changed in programming is ____________.	20 (74.1%)	7 (25.9%)	18 (66.7%)	9 (33.3%)
13. The command directive to line 4 can be written in the programming language.	5 (18.5%)	22 (81.5)	20 (74.1%)	7 (25.9%)
14. The helicopter parameter used to allow it to move up and down is_____________	7 (25.9%)	20 (74.1)	16 (59.3%)	11 (40.7%)
15. The float type is to represent real numbers in basic data. Real data can be declared using _______________.	12 (44.4)	15 (55.6%)	14 (51.9%)	13 (48.1%)
Total points	137.00		223.00	
Mean points	5.96		9.29	

Sixteen of 27 participants (59.3%) strongly agreed that the competition had given them the inspiration to learn and utilize knowledge and skills to a higher level. Furthermore, as many 15 participants (55.6%) strongly believed that the hands-on activities promote their ability to be part of effective teamwork.

The item "I can build a simple electronic circuit" has the highest number of responses, which has a frequency of 19 (70.4%) for the 'Agree' point of Likert scale. Then, it is followed by the item "I am able to understand and modify the coding of the program for this project" with 17 responses (63%). The results showed that the majority of participants claimed after the program, they were able to make a simple electrical circuit and edit the source code of a software. We strongly believed the hands-on activities with Arduino components contributed to students' responses to these items. Interestingly, there were two items highly rated for "Do not know" which "After doing activities in this program, I am interested in furthering my studies in science/technology stream" and "I can identify several types of electronic components and its functions" with 8 (29.6%) and 7 (25.9%) of total responses respectively. The hands-on activity on the smart control helicopter competition was conducted in 1 ½ days and was considered as a short-term STEM program. Even 18 participants showed a definite interest in science or technology fields after the program; still, eight participants responded, "Do not know," and one said "Disagree" categories, which might imply the lack of readiness to continue future studies in the respected fields. One possible reason for the lack of preparedness could be such activity is highly male-oriented. Another reason is perhaps unclear about types of careers related to such an activity. Therefore, future hands-on activity programs, as such, might include putting the activity in a context such as STEM careers related to it, and the activity should be prolonged for a reasonable impact on changing one's interest in the field.

Likewise, a total of 15 points would be given to participants who could answers all the items correctly for the quiz. Important to note that the analysis was based on valid data, even there some missing values found because several participants did not provide an answer to a certain item. Based on data presented in Table 3 and Table 4, the overall performance on participants' technical knowledge of technology and electronics showed changes in the correct responses and total points before and after the competition. The mean total points from pre-quiz were 5.96 and increased to 9.29 on post-quiz. However, the descriptive analysis for items 1, 2, 4, 5, 8, 9, 11, 13, 14, and 15 showed a significant increase in the number of correct responses on the post-quiz from the pre-quiz. The data indicate two items (3 and 6) yielded contradictory results from pre-quiz to post-quiz items. The effects might occur because of the language and knowledge barriers among participants. The correct responses to items 10, 11, and 12 have decreased marginally. However, the correct answers for item 7 have not changed from pre to post-quiz.

Further analysis using cross-tabulation data, as displayed in Table 4, designated a substantial escalation of 22 participants' total points from pre-quiz to post-quiz. The data showed during the pre-quiz, participants who scored as low as 2-point as compared to post quiz with minimum 8-point. Interestingly, the participants who scored the lowest points in pre-quiz were among low achievers in post-quiz and vice versa.

TABLE 4. Change in scores

	Post quiz					
	Total points	8.0	9.0	10.0	13.0	Total students
Pre quiz	2.0	1	1	0	0	2
	3.0	2	0	0	0	2
	4.0	0	1	0	0	1
	5.0	1	1	1	0	3
	6.0	0	2	3	0	5
	7.0	1	2	2	0	5
	8.0	0	0	0	1	1
	9.0	0	2	0	0	2
	10.0	0	0	1	0	1
	total	5	9	7	1	22

CONCLUSION

The facts from the present study showed compelling responses based on data from the questionnaire and quizzes, which indicate that select students valued the hands-on activities of the smart control helicopter program. The module used during the activities might have supported the knowledge construction among the students on technology and electronic components. Although the outreach program was conducted within a short term period, the activities in the module had enabled students to learn and build teamwork skills through the competition. Besides, the program had improved the students' interest in the learning of science and technology through circuit building and program coding. Besides, the university students who were involved throughout the activities showed full commitment and support to the participants. However, this study was limited to the respected respondents; hence a broader sample is recommended for better results.

DECLARATION OF COMPETING INTEREST

None.

ACKNOWLEDGEMENT

The author would like to acknowledge Program STEM dan Minda, code: ZF-2017-011 Grant for providing and support this STEM program as well as involvement from Space Science Centre, Institute of Climate Change, Department of Electrical, Electronic and Systems, Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia (UKM), teachers and students.

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